

REMARKS

In view of the above amendments and following remarks, reconsideration of the rejections contained in the Office Action of April 25, 2002 as respectfully requested.

FORMAL MATTERS

Initially it is noted that a number of minor editorial changes have been made to the specification and abstract so as to generally place the present application into better form.

Furthermore, original claims 1-13 have now been cancelled and replaced by new claims 14-32. Thus the Examiner's rejections of claims 4-5 and 10-11 as being indefinite has been rendered moot. The claims which correspond to these claims have avoided the use of the term "turned V shape", and simply referred to a V shape. As such, it is respectfully submitted to be clear that this rejection has been overcome.

REJECTIONS BASED ON PRIOR ART

Beginning at the bottom of page 2 of the Office Action, claims 1-3 were rejected by the Examiner as being anticipated by Matsuda et al, Japanese reference 63-313007(Matsuda). Claims 4 and 6 were rejected as being unpatentable over Matsuda in view of Hochstein et al., U.S. Patent 4,712,432 (Hochstein). Further, claims 5, 7, 11 and 13 were rejected as being unpatentable over Matsuda in view of Savage et al, U.S. Patent 5,315,881 (Savage). In addition, claims 8-10 and 12 were rejected as being unpatentable over Matsuda in view of Karim-Panahi et al, U.S. Patent 5,438,882 (Karim-Panahi). However, it is respectfully submitted that the present invention, especially as now set forth in each of claims 14-32, clearly patentably distinguishes over Matsuda and the various secondary references cited by the Examiner.

The present invention provides a method and device for measuring the axial elongation of a rotary shaft. The rotor of a gas turbine or a steam turbine undergoes axial elongation due to temperature changes. It is necessary to accurately monitor whether such elongation is within a predetermined range so as to avoid contact between a moving blade and a stationary blade. For this reason, a prior art sensor as described with respect to Fig. 7 has been employed. However,

with this sensor, if the axial elongation is large, use of the gap sensor of Fig. 7 over a wide range often results in less accuracy. Also, with the arrangement of Fig. 7 a certain amount of space is required in the axial direction of the rotary shaft for installation purposes.

Accordingly, the present invention has proposed a different way of measuring the axial elongation of a rotary shaft. Discussing for example the first embodiment, a plurality of marks 10 and 12 are provided on a rotational surface of rotary shaft 1 with at least one of the marks being inclined relative to the axial direction of the shaft. At least one sensor 14 is provided opposite to the rotational surface of the shaft. The sensor is operable to generate pulses when the marks pass the sensor during rotation of the rotary shaft. The axial elongation of the rotary shaft is measured from a change in an interval ratio of the pulses that are generated by the sensor when the marks pass the sensor during rotation of the rotary shaft. That is, as can be appreciated from Fig. 1(a), as the shaft 1 undergoes axial elongation relative to the sensor 14, the position of the marks 10 and 12 will change. Due to their configuration, with at least one of the marks being inclined relative to the axial direction as shown, the point at which the marks are detected relative to each other changes. That is, if the axial elongation was in the leftward direction of Fig. 1(a), the point corresponding to the position of the sensor 14 results in greater circumferential space between the marks 10 and 12, resulting in a longer period of time between detection of the two marks.

This is illustrated by referring to Figs. 2. Time t_1 represents the time from the detection of one mark to the next mark, i.e. from the point of time from the detection of the reference mark to the measuring mark. The time t_2 represents one rotation of the shaft, i.e. the time from the point of detection of the reference mark to the next time the reference mark is detected. As elongation occurs as discussed above, the situation of Fig. 2(b) occurs. That is, time t_{12} now represents the time from the reference mark to the measuring mark.

As discussed in the specification in the paragraph spanning pages 9 and 10, due to the axial elongation of the rotary shaft 1, the pulses generated by the sensor 14 change from an interval ratio of t_1/t_2 in Fig. 2(a) to a ratio of t_{12}/t_{22} in Fig. 2(b). Thus as noted at the top of page 10, by measuring the change in the pulse interval ratio t_1/t_2 obtained by the sensor 14, the

axial elongation of the rotary shaft 1 can be measured. One way of employing this ratio is discussed at the middle of page 10 of the specification.

Another way of determining this ratio is discussed with respect to the second embodiment of Figs. 5 and 6, using two sensors and marks that are axially spaced from each other.

Independent claim 14 is a method claim corresponding generally to original independent method claim 1, and claim 18 is an independent apparatus claim corresponding generally to original claim 2. These are the only independent claims now pending in the application. The various dependent claims incorporate features claimed in the original claims. Thus it may be seen that the claim limitations now presented in claims 14-32 correspond substantially to those of the original claims, with one notable difference.

That is, in independent claim 14, it is now required that the measurement of the axial elongation of the rotary shaft be from a change in an interval ratio of the pulses generated by the at least one sensor, as discussed immediately above. Similarly, in claim 18 there is now required a data processing part that is operable to determine the axial elongation of the rotary shaft from a change in an interval ratio of the pulses generated by the sensor.

The cited Japanese reference to Matsuda does not employ an interval ratio of the pulses to determine axial elongation of the shaft. However, Matsuda employs the pulse time difference ($t_1 - t_2$) from the measurement time in the no-elongation reference time, as illustrated by Fig. 2 of Matsuda, and the rotational speed of the shaft found from the interval between the output signals of the sensors 4 and 5. Matsuda does not teach measuring axial elongation of the shaft by employing an interval ratio of the pulses.

According to the present invention, by determining the axial elongation of the shaft by measuring changes in the interval ratio of the pulses generated by the sensor, the elongation of the shaft can be measured at any rotational speed of the shaft, that is, the rotational speed of the shaft is irrelevant to the determination.

The secondary references cited by the Examiner do not address this aspect of the present invention, and thus do not cure the deficiencies of Matsuda. Applicants reserve their right to traverse all conclusions made by the Examiner regarding what these references further teach.

Specifically, the Examiner's conclusion that the shape of the marks is a design choice is specifically traversed. Rather, the configuration of the marks does indeed affect the operation of the device. Moreover it should be noted that Hochstein relates to a torque sensor, and bears no relation to Matsuda or the present invention. The same can be said of Savage.

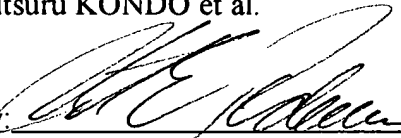
In view of the above, it is respectfully submitted to be clear that the present invention as now set forth in claims 14-32 clearly distinguishes over Matsuda and the secondary references cited by the Examiner. Indication of such is respectfully requested.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance, and the Examiner is requested to pass the case to issue. If the Examiner should have any comments or suggestions to help speed the prosecution of this application, the Examiner is requested to contact Applicants' undersigned representative.

Attached hereto is a marked-up version of the changes made to the specification, and abstract by the current Amendment. The attached page is captioned "**Version with Markings to Show Changes Made**".

Respectfully submitted,

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